bodies, retain the property of producing scintillations on a blende screen, and are non-penetrating].

It seems probable that in these phenomena we are actually witnessing the bombardment of the screen by the electrons[1] hurled off by radium with a velocity of the order of that of light; each scintillation rendering visible the impact of an electron on the screen. Although, at present, I have not been able to form even a rough approximation to the number of electrons hitting the screen in a given time, it is evident that this is not of an order of magnitude inconceivably great. Each electron is rendered apparent only by the enormous extent of lateral disturbance produced by its impact on the sensitive surface, just as individual drops of rain falling on a still pool are not seen as such, but by reason of the splash they make on impact, and the ripples and waves they produce in ever-widening circles.

## THE PSYCHOLOGY AND NATURAL DEVELOPMENT OF GEOMETRY.

IN connection with recent endeavours to place the teaching of geometry on the best possible basis, much interest attaches to Dr. Mach's attempt to trace the order in which geometrical facts first made themselves known in the natural order of evolution.

The earliest notions of space must have been suggested by the relations of physical bodies to the parts of the human body, the spacial behaviour of bodies towards one another subsequently acquiring a mediate and indirect interest far transcending that of the momentary sensations. While the senses of sight and touch only give rise to sensations of surface, crude physical experience soon impels us to conceive the notion of volume, and the *constancy of volume* of bodies would be one of the first attributes to manifest themselves to our senses. Geometry, although asserted to be concerned with ideal objects only, arose from the consideration of the space relations of physical bodies. The earliest units of measurement were derived from our hands and feet. But the material properties of bodies rather than their spacial properties possess the greatest interest for us, and Dr. Mach considers that the first ideas of measurement were those of volume, and arose from counting the number of equal identical immediately adjacent bodies which would fill a given space. The notion of *areas* would be derived from the number of food-bearing plants which a given field would contain or the labour required in planting them, *distance* would be estimated by hours of travel. The measurement of lines and areas by means of *solids* is a notion now completely estranged from our geometrical ideas, but in early times we should have measured lengths and areas by the number of solid bodies placed in line or distributed over a surface required to cover them, an idea which is borne out by the remarkably elegant methods of mensuration expounded in the seventeenth century by Cavalieri.

Although movable bodies present different spacial sensations to the visual sense dependent on the position and distance of the observer, the notion of spacial constancy becomes associated with them both by the sense of touch and by combined experience.

The earliest conceptions of *purely spacial* properties naturally asserted themselves in the pursuit of trades and arts. The property that a number of equal and similar triangles of any shape can be fitted together in regular order to form a pavement or mosaic naturally leads to the property that the three angles of a triangle are together equal to a straight angle. A consideration of the way in which the triangles run in rows would lead to the notion of parallels, and the property that the adjacent angles made by the parallel lines with any transversal are together equal to two right angles. The theorem of the Pythagoreans, according to which superficial space can only be partitioned into regular polygons in three ways, namely, into equilateral triangles, squares, or hexagons, naturally finds its origin in the same source.

A stretched string furnishes the simplest visualisation of a straight line, and leads to the property that a straight line is the shortest distance between two points, but Dr. Mach reminds us that this property cannot be regarded as being established by mere visualisation. It is true that we have learnt instinctively to reproduce in our imagination some method of demonstrating that, for example, two sides of a triangle are greater than the third side, but the source of our knowledge here is *physical experience* derived from our knowledge of material bodies. Another property of straight lines, namely, that a straight line is self-congruent if made to slide or rotate upon itself, is also a result of experience with straight and bent wires.

The knowledge that the measures of geometry depend on one another was reached in divers ways. The division of a parallelogrammatic field into smaller fields gave rise to the area being measured by the product of the length and breadth, and the knowledge that the area of a rectangle is greater than that of a parallelogram having the same sides gave rise to the idea that the area also depended on the angles.

In regard to *angles*, Dr. Mach points out that the definition of an angle as the difference between two directions is a *physiological* definition, the notion of direction being a purely physiological conception. In *abstract space*, obtained by metrical experiences with physical objects, differences of direction do not exist. An angle is determined when the distance is assigned between two points on its arm at given distances from the vertex, but, as Dr. Mach points out, this measure, though closely resembling those adopted in trigonometry, was not used in geometry, because angles so measured would not possess *additive* properties. The simpler measure of an angle by the arc or area which it intercepts on a circle surrounding the vertex thus became generally adopted. In connection with Dr. Mach's views on this point, it may be maintained that even with our present experience of geometry an angle instinctively suggests the idea of *space*, extending, no doubt, indefinitely from the vertex, but possessing the remarkable property of being a definite fraction of the whole space surrounding that point.

The object of geometry is to answer questions that occur repeatedly in the same form, and with this object has arisen the study of deductive geometry, which takes theorems and proves them once for all. But it will be seen that Dr. Mach strongly emphasises the *physical* and *material origin* of geometry, and his studies will naturally support the view that geometry is likely to be best understood when taught in its early stages from the experimental side.

## THE EUCALYPTS.[1]

THE economic importance of the genus Eucalyptus to our Australian Colonies accounts, no doubt, for the somewhat extensive official literature which has grown up there on this subject. This includes numerous publications by the Government botanists and forest officials of the Australian colonies, and especially the classic "Eucalyptographia," now, unfortunately, no longer obtainable, of the late Baron von Mueller, whose enthusiasm for the genus is mainly responsible for the large Eucalyptus plantations now existing in Italy, France, Algeria, California and other countries.

Messrs. Baker and Smith, in their contribution to Eucalyptus literature, give an account of the results they have secured in the course of a systematic study of the Eucalypts, both from the botanical and chemical points of view, and they conclude from the data so obtained that the trees belonging to this genus may be divided into a series of natural groups, in which there is a striking correlation between the structure of the leaves, and to a certain extent, also, of the barks, and the composition of the essential oils produced by the species; thus, in *Eucalyptus tesselaris*, which the authors regard as the primitive type, the leaves have a characteristic parallel lateral venation and furnish

[1] Radiant matter, satellites, corpuscles, nuclei; whatever they are, they act like material masses.

[2] Abstract of a paper by Dr. E. Mach in the *Monist*. Translated by T. J. McCormack.

[1] "A Research on the Eucalypts especially in regard to their Essential Oils." By R. T. Baker, F.L.S., and H. G. Smith, F.C.S. Pp. 295; with 9 plates. (Technological Museum: New South Wales.)

"Eucalypts Cultivated in the United States." By A. J. McClatchie, M.A. Pp. 101; with 91 plates. (Department of Agriculture, U.S.A.)

an oil consisting principally of pinene; this is also the case with about thirteen other species, which together form Group I. in this system of classification. In the succeeding groups, the lateral venation of the leaves becomes gradually more complex, a marginal vein appears, and at the same time the oils produced undergo what may be called a corresponding change; thus pinene is partially replaced by cineol, until, as in the *Eucalyptus globulus*, which the authors appear to regard, probably in deference to its commercial value, as the highest evolutionary product of the genus, this constituent amounts to 60 per cent. of the oil obtained. In the course of this evolution there have appeared several side issues furnishing oils in which cineol is replaced by aromadendral, piperitone, geranyl acetate or citronellal and pinene, wholly or partially by the terpene phellandrene, and in each of these groups, also, there exists a corresponding leaf structure.

Interesting as is this correlation of morphology and constituents in the Eucalyptus species, it may be pointed out that a knowledge of the constituents of a plant is never likely to play such an important part in systematic botany as the authors appear to believe, since there are already known numerous instances of plants which, grown under different climatic conditions, show no morphological change, yet exhibit remarkable variation in constituents, and, on the other hand, plants which are not at all closely related, frequently contain the same colouring matters, alkaloids, &c., so that the necessary specific constancy of constituents, which alone would make such criteria useful, is wanting. The authors lay stress on observations made by them as to the absence of marked variation in the composition of oils yielded by the same Eucalyptus species grown in different districts of Australia, but the evidence of constancy in this respect would be greatly strengthened if it could be shown to hold for the same species grown outside Australia; for an investigation of this kind ample material now exists in foreign plantations.

The principal feature of the volume is, however, the publication of results obtained in the examination of the oils yielded by practically all the Eucalyptus species indigenous to Australia. A short description of the oil obtained, with its physical constants and those of its principal fractions, is appended to the botanical description of each species, and in order to render these more readily available, they are tabulated in special appendices.

The evidence adduced by the authors of the occurrence in the Eucalyptus oils examined of the normal constituents cineol, pinene, phellandrene, &c., is, as a rule, unexceptionable, but occasionally there are lapses which perhaps are due more to the magnitude of the authors' task in recording such a mass of facts than to their lack of scientific thoroughness, *e.g.* a minute difference in the lævorotation of two fractions seems insufficient evidence for the assumption that aromadendral exists in the oil of *E. corymbosa* (p. 26); similarly, the coincidence of the melting point of the nitrosochloride of the terpene of *E. botryoides* with that of pinene nitrosochloride is not conclusive evidence of the presence therein of pinene, and it is usual in such a case to prepare in addition the nitrol-piperide or similar derivative. The evidence given for the occurrence of a valeric acid ester in *E. umbra* (p. 37) is worthless, whilst the lemon-like odour of a particular fraction of the oil of *E. fraxinoides* scarcely warrants the assumption that it is due to citral without characterisation of this aldehyde by the preparation of at least one of its readily obtained derivatives. The authors also appear to be unaware that the reaction (p. 235) which they employ for the identification of geraniol, viz. its oxidation to citral by chromic acid, is equally well given by the isomeride linalool. The formation of an alcohol (cineol) of the composition $C_{10}H_{18}O$ (p. 223) by the oxidation of an aldehyde (aromadendral) of the composition $C_{10}H_{14}O$ is, if it really occurs—and on this point the evidence is slender—a unique reaction, and requires further investigation. It seems unfortunate, also, that whilst the specific rotation and solubility of the oils have invariably been determined, the authors did not utilise their unique opportunity to record such useful constants as the refractive index and dispersion. Exception must also be taken to the use of the name eucalyptol in place of cineol in a scientific publication of this kind.

The volume, as a whole, is remarkably well printed, and the plates depicting leaves of the typical groups clearly exhibit the characteristic features to which attention is drawn in the text.

The mere collection of the material necessary for an elaborate investigation of this kind is a task of considerable magnitude, and when there is added to this the tedious experimental work involved in the investigation of a large number of oils of similar composition, some idea may be obtained of the industry and perseverance the authors have expended on this work. The results should be of inestimable advantage to the colony far-sighted enough to encourage the prosecution of such investigations.

The American volume is intended primarily to enable forest proprietors to identify the Eucalyptus species in their possession, and is therefore largely a compilation of the diagnostic characters of the fifty odd species which have been introduced into the south-western States. The author, however, devotes some space to extolling the ornamental and useful character of these trees, and points out their value, particularly as wind breaks, shade trees, improvers of climate and as sources of timber and essential oil. The virtues of the latter, when of American origin, are described in language somewhat reminiscent of the advertisements of transpontine proprietary medicines. The chemistry of the volume is occasionally at fault, as, for instance, when it is stated that (p. 13) "the exudations from the trees are in most cases *not* gums, but resins," and "the chief ingredient of the lemon-scented Eucalypt is *citronellon*" (p. 39). The volume is, like most of the publications of the U.S. Department of Agriculture, well printed and copiously provided with useful and artistic illustrations.

T. A. HENRY.

## OPPOSITION OF MARS.

MARS is now brightly visible during the whole night, and well placed in the sky for observation. He occupies a position on the equator in Virgo, but the present apparition is not really a favourable one, the distance of Mars from the earth on the date of opposition (March 28) being nearly sixty millions of miles. The apparent diameter of the planet, as given in the *Nautical Almanac*, will be $14''\cdot6$; this is only half the value ($29''\cdot5$) which the planet presented in the best circumstances in August, 1892, and September, 1877. At those periods, however, the declination of Mars was more than 24° south of the equator, so that telescopic observations were rendered very difficult at stations in high northern latitudes. A comparison of the last few oppositions of this planet gives the following figures:—

| Opposition. | | h. | Apparent Diameter. ″ | Declination. ° ′ | Distance. Millions of Miles. |
|---|---|---|---|---|---|
| 1894, October | 20 | 10 | 25·6 | + 8 32 | 40 |
| 1896, December | 10 | 18 | 16·6 | +25 39 | 52 |
| 1899, January | 18 | 12 | 14·4 | +24 42 | 61 |
| 1901, February | 21 | 18 | 13·8 | +14 36 | 63 |
| 1903, March | 28 | 20 | 14·6 | − 0 7 | 60 |

Though the conditions under which Mars is now displayed compare unfavourably with those at a really good opposition, it is quite possible to distinguish a large amount of detail on the disc. The principal features are very dark and well pronounced, and may all be recognised under pretty high powers. Fortunately, Mars satisfactorily bears more extreme magnification than Jupiter. In studying the latter object with a 10-inch reflecting telescope, the writer has found a power of 252 very efficient and 312 ample for every purpose, but on Mars the most serviceable powers appear to be from 332 to 488.

The study of Mars is essentially different in character from that of Jupiter. The latter does not exhibit his real disc, but a series of vaporous, longitudinal currents, in which are floating a number of changing spots of various tints. Mars shows real surface markings, which appear subject to certain temporary differences due to atmospheric interference. In fact, the aim of an observer of Mars is to distinguish the outlines of the markings in a comprehensive